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UTILIZATION OF WIND POWER IN AGRICULTURE IN THE USSR

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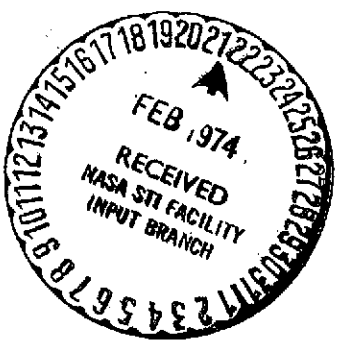

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16. Abstract

Wind motors are being used in Russian agriculture for milling and pumping water. Plans call for rapid expansion of the utilization of such power plants. The extent of present utilization, problems, and forecasts are outlined.

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UTILIZATION OF WIND POWER IN AGRICULTURE IN THE USSR

Dimitry Stein

Development

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Research into the questions involved in the utilization of wind power has been systematically conducted in the Soviet Union since 1918. At that time, the Academy of Sciences began to study wind motors and their applications in agriculture. A comprehensive investigation of these questions was started in the years 1920 to 1922 in the National Aerodynamic Institute (TsAGI). In 1931, the researches were transferred to a special "Central Wind-Energy Institute" (TsVEI), which worked on research into the aerodynamic problems of the windwheel, on improving the possibilities for wind motor control, and on the investigation of wind power plants for direct and alternating current. All these works led to favorable results, so that many technical and scientific problems had been solved to such an extent by 1935 that the construction of wind motors with powers of 1000 hp could be initiated.

Based on experiments which had been conducted, a wind motor was then built with a control designed by Prof. Sabinin and Dr. Krasowski, which guaranteed operation uniform to within 1.5 to 2.5%. Such a wind motor has been in operation for 4 years in the Arctic with good success. The wind power plants likewise proved themselves. The wind power plant TsAGI-TsVEI in Crimea, according to Russian figures the largest in the world, has been in continuous operation since 1930, and generated, for example, about 8500 kWh in the first 20 days of December 1939.

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* Numbers in the margin indicate pagination in the foreign text.

In 1935, the Central Wind-Energy Institute was dissolved. Its responsibilities were taken over by the People's Commissariats for Agriculture and for Heavy Industry. The People's Commissariat for Agriculture was to work on wind motors with powers up to 100 hp, and, in particular, on employing them together with pumps, current generators, and agricultural machines. The questions connected with high-power wind motors and wind power plants were transferred to the People's Commissariat for Heavy Industry.

Significance of Wind Utilization in the Russian Energy Budget

The extensive introduction of wind motors has very great significance for the energy budget of the USSR. For some time now, there have been references in the Soviet-Russian daily and professional press, and in the speeches of leading personalities, to the fact that the energy extracted from coal and oil reserves must be replaced, wherever possible, by hydroelectric or wind power. This is justified not only by the large growth in industry as a whole and in air and ground transportation, but particularly by the necessities of the armed forces. With complete mechanization, agriculture would constitute the most energy-demanding portion of the Soviet economy. As of 1938, 21.5 billion kWh would be necessary annually in order to cover the principal needs of agriculture completely with electric power. Recalling that the actual corresponding energy consumption in the same year was only 382 million kWh, i.e. only 1.78% of the cited number, it can be gauged how large the energy requirement is here. /55

As a comparison, here are some other figures: In the year 1938, all the power plants in the Soviet Union together, with an installed power of 8.7 million kW, generated a total of 39.6 billion kWh energy. By 1942, the power of the plants is to have grown to 18.3 million kW, and the generated energy to 83.5 billion kWh. For the year 1952, 250 billion kWh is anticipated, i.e.

about 200 billion kWh more than in 1939. Considering that the demands of cattle raising alone amount to 8.646 billion kWh, i.e. 34% of the energy requirement of agriculture, this would require 10.4% of the total energy generation in the year 1942. If wind power were to be used in agriculture only where its employment were clearly economic, i.e. for water distribution in cattle-raising (estimated at 630 million kWh) for 1942), for supplying the population with water (1210 million kWh), for milling (1870 million kWh; in all, therefore, 3710 million kWh), this would save a significant amount of fuel for the Russian economy. With a consumption per kWh of 0.65 kg with a heating value of 7000 kcal/kg, the saving would be 0.65 x 3.71 = 2.4 million tons.

What is to be the source of these amounts of energy for the electrification of agriculture? Authorities have given a clear anwser in a resolution of the Party Congress. In the future, the erection of small water power and wind power plants and generator-gas plants using peat is to be undertaken on a large scale.

Utilization of Wind Power in Agriculture

Of the three sources of energy, water, wind and fuel, only wind is available everywhere. The employment of wind energy is extremely important for the electrification of agriculture, even if the irregularity of the wind rules out this form of energy for certain types of work. At any rate, wind motors constitute a very useful source of energy for water supply and for milling. About 418 million kWh could have been usedin 1938 just for water supply in cattle raising. As mentioned earlier, this need is estimated at 630 million kWh for the year 1942. The production of all operating wind motors will amount by this date to about 195 or 432 million kWh at wind speeds of 4 or 6 m/sec, respectively (Table 1), i.e. 31 or 68% respectively of the energy required for water supply will be delivered by wind motors.

TABLE 1. DETAILS ON THE PRODUCTION OF THE FACTORIES OF GLAVSEL'MASH IN THE PERIOD FROM 1938 TO 1942

	Wind motor type and windwheel diameter									
	VIME-D3, high-speed, with 3 blades	VISHOM-D3[4], high-speed, with 3 blades	VIME-D5, high-speed, with 3 blades	PD-5, high-speed with many blades	TV-5, low-speed with many blades	TV-8, low-speed with many blades	VIME-D12, high-speed with 3 blades	VIME-D18, high-speed with 3 blades	TsVEI-D24, wood-metal construction with 4 blades	VIME-D30, high-speed with 3 blades
Rated power at a wind velocity of v = 8 m/sec at shaft of windwheel (in hp)	0,60[1])	0,90[1])	2,7[1])	2,7[1])	8,5[1])	6,5[1])	14[1])	32[1])	60[1])	90[1])
Rate of revolution of windwheel at full load (v = 8 m/sec) (rpm)	300	—	180	—	40	26	60	60	20	25
Rate of wind motor without tower (in kg)	444	—	575	—	1 291	1 950	2 755	—	—	25 600
Price from factory in mass production (rubles)	—	—	—	—	2 700	6 000	—	—	—	
Annual production from 1943 (numbers)	2 600	3 000	2 500	—	6 000	9 000	5 300	200:	Tot.	28 500 hp
Installed power (hp)	1 050	900	6 250	—	12 600	64 000	79 500	7 000:	Tot.	161 200 hp
Annual generation of a motor at mean annual wind velocity of v_0 = 4 m/sec (kWh)	912	912	2 600	2 600	2 780	9 450	14 625	33 000	58 600	91 000
The same at v_0 = 5 m/sec (in kWh)	1 322	1 322	4 133	4 133	3 940	15 000	24 105	64 200	96 600	150 000
The same at v_0 = 6 m/sec (in kWh)	1 672	1 672	5 600	5 600	5 000	21 000	33 506	75 600	132 900	207 000
Annual generation of all wind motors at mean annual wind velocity of v_0 = 4 m/sec (in millions of kWh)	3,18	2,74	6,5	—	13,8	85,0	77,5	6,5 :	Tot.	195 220 000 kWh
The same at v_0 = 5 m/sec (millions of kWh)	4,6	3,96	10,3	—	19,7	135,0	127,0	10,82:	Tot.	311 380 000 kWh
The same at v_0 = 6 m/sec (millions of kWh)	5,85	5,0	14,0	—	25,0	189,7	178,0	15,10:	Tot.	431 950 000 kWh
Annual duration of use at a mean annual wind velosity of v_0 = 4 m/sec (in hours)	6 755	6 755	6 755	6 755	6 755	6 755	5 310	3 700	3 700	3 700
The same at v_0 = 5 m/sec (in hours)	7 525	7 625	7 525	7 525	7 525	7 525	6 522	5 212	5 212	5 212
The same at v_0 = 6 m/sec (in hours	8 025	8 025	8 025	8 025	8 025	8 025	7 325	6 362	6 362	6 362

[1] Experimental plants
[2] Wind motors in current production
[3] Constructed at the site out of wood. Factory provides only metal parts
[4] [sic]

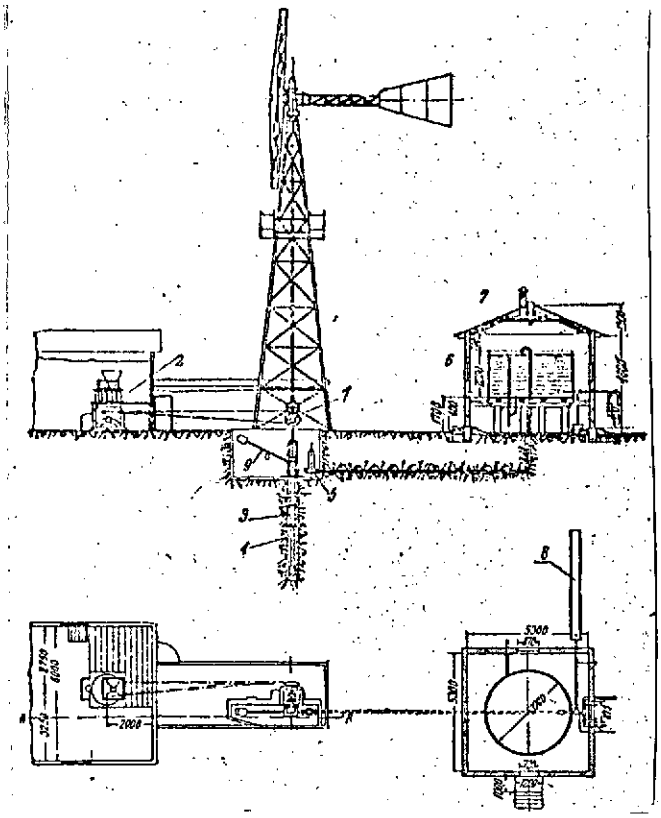

Fig. 1. Wind power plant TW-8 for pumping water and milling.
1. gearing; 2. milling machinery; 3. pump; 4. protective pipe; 5. air chamber; 6. container for 20 m^3 water; 7. preheater; 8. water trough for cattle; 9. lift arm

The experimental installations and factories of the USSR have in recent years turned out numerous wind motors suitable for the purposes described, and some of them have already proven themselves quite well. A survey of wind motors both planned and in production is given in Table Of the facilities mentioned in it, the greatest attention has been devoted to the TV-8 wind motor, which is already in mass production. By the end of the year 1942, 9000 of these wind motors are to be in use in agriculture. Therefore, a more detailed description and especially a study of the economy of this facility is of interest.

Fig. 1 shows the wind power plant TV-8, which is intended for alternation between water supply and grain milling. Water pumping is to deliver 30 to 15 m^3/day (depending on the time of year) with a pressure height of 30 m. This is sufficient to supply 150 head of cattle, 300 sheep, and 200 hogs. A 20-m^3 container serves as a water reserve for windless days. In case of longer windlessness, the plant can be driven by two horses. Table 2 shows the annual production of the TV-8 facility at different wind speeds. /56

TABLE 2. ANNUAL PRODUCTION OF PLANTS TV-8 AT VARIOUS WIND VELOCITIES

Mean annual wind velocity (m/sec)	3	4	5	6
Annual work at the gear shaft allowing for applicable efficiency and repair times (300 hours) (hp-hour)	5000	9200	13,300	16,900
Horse driven	500	300	200	150
Together	5500	9500	13,500	17,050
Work requirement for water pumping at 8100 m^3 per year (hp-hour)	1390	1400	1390	1390
Work requirement for milling (hp-hour)	4110	8100	12,110	15,600
Production of mill at a rate of 20 kg/hp-hour (tons)	82.2	162.2	242.0	312.0

Costs of the TV-8 Facility

1. Volume beneath the milling plants: 5 x 6 x 3.5 = 105 m^3. About 45 rubles per cubic meter. 4700 rubles

2. Wooden container for 20 m^3 water with mechanism and preheating chamber 4600 rubles

3. TV-8 wind motor with pump plant and delivery 4500 rubles

4. Installation of the wind motor and the pump facility 1000 rubles

5.	Milling plant with installation	4500 rubles
6.	Horse drive with mechanisms	400 rubles
		19,700 rubles
1.	Capital (amortization) for buildings, wind motor, water container, and furnishing, 6% of 19,700 rubles	1180 rubles
2.	Upkeep of the building, 2% of 4700 rubles	94 rubles
3.	Upkeep of equipment, 3% of 14,000 rubles	420 rubles
4.	Mechanic	2600 rubles
5.	Lubrication and cleaner	80 rubles
6.	Horse work, 20 rubles/day	depends on duration of no wind

These values lead to the operating costs for the TV-8 facility given in Table 3 for various wind speeds. It can be seen that using wind motors for hauling water and milling can result in significant cost savings over the other power sources. Even with a low mean annual wind velocity of 4 m/sec, the wind motors operate more inexpensively than gasoline engines. Fig. 2 plots the costs of the VIM-D12 wind motor as a function of wind speed.

Practical Experience in the Construction of Wind Motors

The construction of wind motors in Russian agriculture goes back mainly to the year 1936. At first, the successful operation of these facilities was impaired by various defects. While the

errors in production were soon eliminated, the errors due to poor organization at the operating site and the lack of trained personnel have not yet been corrected.

TABLE 3. COSTS OF THE TV-8 PLANT

Mean annual wind velocity (m/sec)	3	4	5	6
Annual outlays for operation of the plant (rubles)	5615	5124	4874	4754
Cost of 1 hp-hour of useful power (rubles)	1.025	0.54	0.36	0.28
Cost for pumping 1 m^3 water, pressure head 30 m (kopeks)	17.7	9.3	6.2	4.8
Cost for milling 1 tone of material (rubles)	51	27	18	14

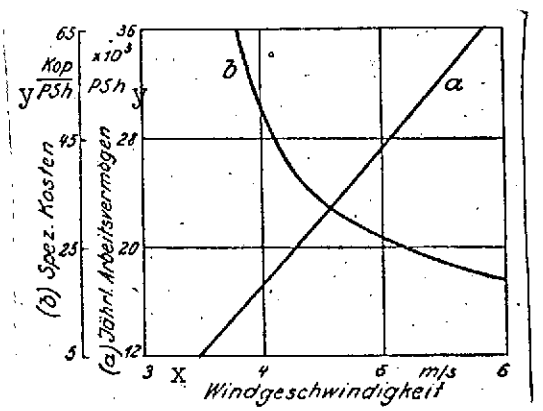

Fig. 2. Energy-generation costs of the VIM-D12 wind power plant as functions of wind velocity. a. Annual generating capacity at an efficiency of 0.8 (in thousands of hp-hour); b. cost of 1 hp-hour (in kopeks).

Key: x. Wind velocity (m/sec); y. hp-hour

The construction of every wind power plant must be preceded by an exact calculation of the extent of operations, the type of operation, and the economic conditions for the plant. In some collective economies, insufficient attention is devoted to these considerations, so that the wind motor either runs with inadequate loads, i.e. operates uneconomically, or else is overloaded, resulting in mechanical damage. For this reason, the Union Institute for Mechanization and Electrification of Agriculture (VIME) has recently worked out several proposals for the

construction of wind power plants, on which the planning of new plants is to be based.

The lack of trained service personnel is a phenomenon which can be recognized in all of Russian industry and economy. It can be attributed to the "American-speed" industrialization of the Russian economy carried out since the beginning of the first 5-Year Plan in 1928. The state is directly great efforts to controlling this lack of professional people. Fwr example, a law was recently promulgated calling for the training of 800,000 young people annually in vocational schools. A work force is to be educated in the operation and maintenance of wind motors in agriculture. Due to the relative simplicity of the plants, this should not be very difficult.

Wind motors have proven themselves in numerous collectives of the Soviet Union as a whole. Thus, three BD-8 wind motors were set up on a state farm in the Ukraine in 1936. Since then, they have continuously provided water for 3000 head of cattle. After the installation of the wind motors, the farm saved 32,400 rubles annually in labor costs. Similar reports have also come from other regions.

Production of Wind Motors

As already mentioned, the factories of Glavsel'mash have been producing wind motors in significant quantities since 1936. Just in the period from April to October 1936, Russian agriculture acquired 1300 wind power plants. In spite of the great need for such motors, production has risen relatively slowly. Measures have therefore been taken by the People's Commissariat for Medium-Sized Machine Construction in order to accelerate the construction of wind motors. According to the plan, 28,500 wind motors with an installed power of 161,200 hp are to be produced

every year after 1943 (cf. Table 1). In the Russian view, this is to be the beginning of a large-scale utilization of wind energy in agriculture.

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